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AN ANNOTATED BIBLIOGRAPHY ON THE

INTERRELATIONSHIP OF ELK AND ROADS

by

Lewis Brown

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Robert Jones

Technical Bulletin 89-2

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BUREAU OF LAND MANAGEMENT
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Introduction

Beginning in the 1960s, accelerated timber harvest coupled with increased hunting pressures brought about conflict over the management of elk habitat. In response to these pressures, numerous research efforts were initiated by the game departments and various federal agencies in several states. These studies spanned the years from the early 1970s through the mid 1980s.

The purpose of this bibliography is to gather together citations from most of the literature that deals with the impacts of roads on elk and elk habitat. It is not an exhaustive effort since many reports, especially the earliest ones are no longer available. This information is intended as a guide to the most available and comprehensive of the material that was written on the subject. The references listed in this bibliography are on file in the BLM's Denver Service Center library. Many are also available from the BLM Idaho State Office library.

Where possible summaries of the information is given using the author's abstract. In cases where the abstract was excessively long the most pertinent text was excerpted. In some cases, an abstract was not available, and we summarized the information.

Although abstracts are useful in getting at the gist of the original text, they should not be substituted for the text.

References

Anonymous. 1978. Elk-roads-logging relationships, a current resume of findings. U.S.D.A. Forest Service. Intermountain Region.

The objective of this paper is to provide a state-of-the-art literature review of elk and logging management with particular reference to the Intermountain area. Results from the review indicate a mixed bag of impacts on elk from logging activities. References reviewed and discussed include: increased forage production following timber harvest, effects of roads on elk, forest management practices, and general wildlife considerations.

Basile, J.V. and T.M. Lonner. 1979. Vehicle restriction influence elk and hunter distribution in Montana. Journal of Forestry. 77(3), pp. 155-159.

Restricting vehicle use on portions of two areas in Montana led to contrasting results in overall hunting pressure, in seasonal distribution of hunters and of elk, and in elk harvest. The Judith River area of the Lewis and Clark National Forest was two-thirds forested with interspersed clearcuts and natural openings; here hunting pressure increased 26 percent, but distribution through the seasons was unchanged. Conversely, on the Ruby River area of the Beaverhead National Forest, essentially open grassland with scattered islands of timber, overall hunting pressure did not change significantly, but was more uniformly distributed through the seasons when travel was restricted. The numbers of elk seen and killed per hunter each increased 28 percent under vehicle restrictions on the Judith River area. However, the uniformity of sightings and kills through the seasons increased markedly on the Ruby but not on the Judith. Differing responses were believed due mostly to differences in total forest cover on the two areas. Hunters spent more time walking, and consequently saw more elk under restricted travel conditions than under unrestricted travel. (Author's abstract)

Beall, R.C. 1976. Elk habitat selection in relation to thermal radiation. In: Proceedings, Elk-logging-roads symposium. University of Idaho, Moscow, ID. pp. 97-100.

Elk react to changing ambient air temperature and solar and thermal radiation conditions by selecting bedding sites which enhance control of body temperature. As air temperature increased, elk beds shifted sequentially to north slopes during the day and south slopes at night. The number of trees per acre in selected day bed sites also decreased. In all cases of habitat selection under varying meteorological conditions a closer correlation was found with thermal and solar radiation intensities than with ambient air temperatures. (Author's abstract)

Brekke, E.B. 1988. Using GIS to determine the effects of CO2 development on elk calving in south-central Colorado. Tech. Note 381. U.S.D.I. Bureau of Land Management. Denver Science Center. pp. 36.

The ARCO Oil and Gas Company funded a study to determine the impacts of full-scale drilling activities on elk calving and to record elk responses to associated human disturbances such as use of roads in the calving area. Findings indicated the CO2 development project caused a significant shift in elk distribution around the drill sites located within the calving areas. Management recommendations included; develop roads and other facilities in shortest possible time, place them in areas least used by elk, place them in sites that are less visible to elk, and maintain security cover adjacent to roads and drill sites.

Bright, L.R. 1981. Elk habitat inventory and mapping utilizing LANDSAT Satellite data. Wildlife Research Report No. 11, Oregon Department of Fish and Wildlife, Portland, OR. 33 pp.

LANDSAT imagery was used to inventory and map approximately 260,000 ac. of Rocky Mountain Elk habitat within the Heppner Wildlife Management Unit, Morrow County, Oregon. Habitat components such as thermal cover, hiding cover, and forage areas as well as mileage for three classes of roads were mapped. The total potential elk use was calculated for the Wilson TRI - compartment as an example of how to use cover and forage data, roading impacts, and size/spacing information. (Excerpted author's abstract).

Brown, C. 1985. Sand Creek elk. Job completion Report. Project No. W-160-R. Idaho Department of Fish and Game. 119 pp.

An interagency study of elk movements and habitat uses from the period of January 1981 to May 1985. One section documents the avoidance of Highway 33 in the winter range. Area affected by the traffic use on the road was documented out to 1500 m.

Burbridge, W.R., and D.J. Neff. 1976. Coconino National Forest-Arizona Game and Fish Department cooperative roads - wildlife study. In: Proceedings, Elk-logging-roads symposium. University of Idaho, Moscow, ID. pp. 44-57.

Big game use and hunter use and success are being studied on two adjoining areas of the Coconino National Forest. One area is annually closed to motorized vehicles. Weather appears to be the major influence on big game distribution; however, cattle grazing also has an influence. A "refuge effect" has not been observed in the area closed to motor vehicles.

Information on the intensity and seasonality of motor vehicle travel has been gathered in the study area. The level of vehicle travel in the spring and summer, during the big game reproductive periods, is light and probably insignificant in impact. In the fall, when traffic is heavier, the closed area offers no refuge because a considerable number of hunters are active on foot. Hunters will support small area road closures, although deer and especially elk hunters are concerned with game retrieval. The road closure has not significantly altered deer and elk hunter use or access in the study area. There appears to

have been a slight decline in turkey hunters in the closed area, traceable to the fact that many fall turkey hunters are road hunters.

Collins, W.B., P.J. Urness, and D.D. Austin. 1978. Elk diets and activities on different lodgepole pine habitat segments. Journal of Wildlife Management. 42(4). 799-810.

The biweekly diets of tame elk (Cervus canadensis) were established on a species dry-weight basis for different habitat segments in the lodgepole pine (Pinus contorta) type. Principal species in the diets (those comprising 5% or more) on each habitat segment were generally composed of preferred species. However, some highly abundant but nonpreferred species took on principal dietary status, whereas some preferred species, scarce in the vegetation, contributed less than 5 percent to diets. Forbs contributed most to total diet; grasses and sedges were the second largest contributors. Browse appeared to be of limited importance, but mushrooms had special significance in forested habitat segments. Preference changes were evident as forb species matured. Consumption rates were significantly higher in habitat segments having greater species diversity and forage density. The time tame elk spent grazing, ruminating, lying, grooming, traveling, standing, drinking, and playing was referenced to specific habitat segments in which each activity occurred. One thousand and eight hours of individual elk activity were observed over a series of 6 24-hour periods. Wet meadows, dry meadows, clearcuts, and revegetated roads were preferred as grazing sites, while mature and stagnated forests were clearly nonpreferred. Wet meadows, revegetated roads, and mature forest were preferred for resting and nongrazing activities. (Author's abstract)

Devlin, D.A. and J.L. George. 1979. Forage utilization by elk and white-tailed deer on two clearcuts in Elk County, Pennsylvania. In: North American elk: ecology, behavior and management. Boyce, M.S. and Hayden-Wing, L.D. eds. University of Wyoming. Laramie, Wyoming. pp. 98-104.

Randomly placed exclusion cages were used to determine biomass utilization of volunteer (naturally occurring) vegetation on clearcuts and seeded plants on access and logging roads by using the clipped dry weight differences between caged and uncaged samples. Results indicate that both elk and white-tailed deer used the seeded roads in spring, whereas in the early fall, elk were the primary users of these areas. Utilization of volunteer vegetation was found to be significant in summer due to the heavy use of blackberry by both elk and white-tailed deer. Utilization of volunteer forage species was determined using the differences in species densities from caged and uncaged areas. Significant differences in species densities were noted for blackberry and woody stems. Using these data, several management implications are suggested.

Edge, D.W. and C.L. Marcum. 1985. Movements of elk in relation to logging disturbances. Journal of Wildlife Management. 49(4):926-930.

Elk (Cervus elaphus) movement in relation to logging activities were studied in Chamberlain Creek, Montana, between 12 August and 30 September 1981. Fifty-six aerial and 61 ground telemetry locations were obtained for nine cow elk. Normal elk movements in the Chamberlain Creek area were short and probably related to forage availability. Movements away from disturbance were significantly longer than those toward disturbance, but the sequence of movements was random with respect to source of disturbance. Elk tended to move into areas of logging activity on weekends during non-active periods, but habituated to the disturbance. A buffer zone of 500-1,000 m separated areas of high elk use from areas of disturbance. Habituation may decrease this buffer zone. This displacement of elk may cause substantial reduction in habitat availability. (Author's Abstract)

Edge, D.W., C.L. Marcum, S.L.O. Edge. 1987. Summer habitat selection by elk in Western Montana: A Multivarinte Approach. J. Wildlife Manage. 51(4): 844-851.

A study to identify the important components of elk (Cervus elaphus) habitat, through discriminant comparisons of elk-selected and random habitat samples, was conducted between mid-June and mid-October 1982 and 1983. Seventeen variables were measured from aerial photographs, maps, or in 375-m2 plots for 354 radio-monitored and 172 random locations. Stepwise discriminant analysis was used to test the hypothesis of equal mean vectors between monthly elk locations and random sites. Elk locations differed between months and from random locations ($P<0.01$). The most important variables were slope, the amount of foraging area within 200 m of each location, and distance to open roads and human disturbance Site-specific habitat characteristics were not apparent in the data because elk made broad use of available habitats. Summer-long habitat for elk can be evaluated from maps and aerial photographs. (Author's Abstract)

Geist, V. 1978. Behavior. pp. 283-296. In: Big Game of North America, Schmidt, J.L., and D.C. Gilbert, eds. Stackpole Books. Harrisburg, P.A.

Geist's chapter includes those aspects of animal behavior that aid the big game manager in reaching their management goals. Harassment of big game is singled out for somewhat more detailed discussions. Three conclusions Geist draws when dealing with big game management problems and animal behavior are: 1) knowledge of the behavior and biology of local populations is necessary; 2) generalizations are warranted only when and where great care is exercised; and 3) verification of assumptions is most desirable.

Gillin, C.M., and L.L. Irwin. 1985. Response of elk to seismograph exploration in the Bridger-Teton National Forest, Wyoming. University of Wyoming, Department of Zoology and Physiology. 53 pp.

This study documented displacement of radio-collared elk within their home ranges by an average of 3/4 mile. This was especially true for elk on calving ranges and on alpine summer ranges. Elk tended to move out of open areas into dense forest types and more secluded areas away from roads. These areas were usually areas of lower forage production.

Grossarth, O.D. 1981. Elk-timber relationships of west-central Idaho. Idaho Department of Fish and Game/Bureau of Land Management/U.S. Forest Service. 37 pp.

This paper provides land managers on the Boise and Payette Forests a means to assess and evaluate the affects of silvicultural practices, timber harvest techniques and other land management actions on elk and their habitat.

Grover, K.E. and M.J. Thompson. 1986. Factors influencing spring feeding site selection by elk in the Elkhorn Mountains, Montana. Journal of Wildlife Management. 50(3): 466-470.

Elk (Cervus elaphus) spring feeding site selection as influenced by 12 environmental variables was investigated in the Elkhorn Mountains of southwestern Montana during 1983-84. Variables included cattle use, plant community descriptions, distance to disturbance sources, and topographic descriptors. In multiple regression we were able to account for 68% of the variation in elk spring feeding site selection. Elk selected feeding sites that were previously grazed by cattle and supported relatively high densities of bunchgrass plants. Elk made the greatest use of these sites when they were located near cover and away from visible roads. (Author's abstract)

Gruell, G.E. and G. Roby. 1976. Elk habitat relationships before logging on Bridger-Teton National Forest, Wyoming. In: Proc. Elk-logging-roads symp., University of Idaho, Moscow, Id. pp. 110-121.

Telemetered elk data and time-lapse photography showed that infrequently used four-wheel drive roads had minimal impact on elk during the summer. During hunting season, elk avoided localities where the roads were used.

Hayden-Wing, L.D. 1979. Distribution of deer, elk, and moose on a winter range in southeastern Idaho. pp. 122-131. In: North American Elk: ecology, behavior and management. Boyce, M.S., and Hayden-Wing, L.D., eds. University of Wyoming, Laramie, WY 294 pp.

The distribution of mule deer (Odocoileus hemionus hemionus), Rocky Mountain elk (Cervus canadensis nelsoni), and Yellowstone moose (Alces alces shirasi) was studied on a winter range of stabilized dune sand in Freemont County, Idaho during the winter of 1961-62. Both visual observations and pellet group counts indicated very little overlap in the areas used by these three species. Deep snow evidently restricted deer distribution to the few south-facing slopes on the area. The available browse on these slopes reflected the cumulative impact of years of intensive winter deer concentrations and was less vigorous than elsewhere. Elk distribution appeared to be influenced primarily

by man's activities and secondarily by snow depths and vigor of browse. Within those portions of the winter range farthest removed from human activities, elk concentrated on areas of moderate snow depth where good browse forage was available. The distribution of moose was apparently affected most by the vigor and distribution of chokeberry (Prunus virginia var. demissa) on the range. Moose consistently sought out the largest, most vigorous stands of chokecherry and did not appear to be affected by either man's activities or snow depths that excluded deer and elk.

Hershey, T.J., and T.A. Leege. 1976. Influences of logging on summer range in north central Idaho. In: Proceedings, Elk-logging-roads symposium. University of Idaho, Moscow, ID. pp. 73-80.

A study of elk distribution, movements and habitat selection with respect to clearcuts, roads and human disturbance was conducted on summer range in north-central Idaho in 1974 and 1975. Elk avoided using areas within 0.4 km (0.25 miles) of primary and secondary roads and showed a high preference for areas farther than 0.4 km from a road. Elk were located closer to roads in November than in any other month. Opening of the general elk season in October did not influence elk distribution with respect to mean distance from nearest primary and secondary roads. The distribution of radio fixes on two cow elk and 25 hunter kills within 3.2 km (2 miles) of three active cutting units indicated elk did not move away from low intensity, short-term logging disturbance. (Excerpted author's abstract.)

Hershey, T.J., and T.A. Leege. 1982. Elk movements and habitat use on a managed forest in north-central Idaho. Wildlife Bulletin No. 10, Idaho Department of Fish and Game. 24 pp.

Seasonal elk movements, distribution and habitat preferences were investigated on a managed forest in north-central Idaho from June 1974 through August 1977. Ground and aerial surveys provided 289 visual sightings of 1,088 marked and unmarked elk, and radio telemetry provided 900 relocations of 9 radio-collared elk. We estimated that about 300 elk summered on the study area. The observed cow:calf:bull ratio averaged 100:52:19 during the study.

Old-growth grand fir associated with poorly drained, cool, moist land types were important habitat features during late summer and early fall. Clearcuts received greatest use in spring, early summer and late fall. When using clearcuts, elk selected areas where slash was removed by broadcast burning, and areas within 92 m of timber.

Disturbance from human activity was an important factor influencing elk distribution in our study. We observed displacement of elk from hunting, logging and motor vehicles. Degree of displacement appeared to be related to proximity, intensity and duration of disturbance.

Access roads for timber harvest strongly influenced elk hunter and harvest distribution. A greater harvest rate was evident for animals within 800 m of a road. Results from a questionnaire indicated that many sportsmen favored road closures. (Excerpted author's abstract.)

Hieb, Susan R. 1975. Proceedings of the Elk, Logging, Roads Symposium, Moscow, Idaho, December 16-17, 1975. University of Idaho. 142 p.

Contains 18 papers dealing with the impact of logging and road use on elk.

Houston, D.B. 1982. The Northern Yellowstone Elk, Ecology and Management. McMillan Publishing Co., New York, NY, pp. 474.

This reference summarizes elk ecology and management in a setting where less than 0.3% of their northern winter range is affected by human developments including roads. It discusses habitat preference and utilization levels. The references also gives an example of how susceptible wintering elk are in roaded areas where hunting is permitted, i.e. 1283 hunters took 1,121 elk in 1976. This pressure significantly altered the movement of the animals out of the parks onto their wintering area.

Irwin, L.L. and J.M. Peek. 1979. Relationship between road closures and elk behavior in northern Idaho. In: North American elk: ecology, behavior and management. University of Wyoming. Laramie, Wyoming. pp. 199-204.

From 1975 through 1977 a radio-tracking study of elk (Cervus elaphus) habitat use patterns in relation to forest management, hunters, and roads was conducted in western hemlock (Tsuga heterophylla) and grand fir (Abies grandis) forest in northern Idaho. Half of the study area was in various stages of secondary succession following a 1931 wildfire; the remainder was old-growth western hemlock. Nine elk were monitored: four during 3 successive hunting seasons, one during 2 seasons, and four during 1 season. Vehicular access was unrestricted in 1975, and prohibited from 1 September to 1 November in a 40 km area in 1976 and a 75 km area in 1977. Traffic counters on main roads in 1975 and 1977 indicated total numbers of hunters did not change in the general area. Although six of the radio-collared elk were harvested during the three years, it was undetermined whether or not hunting success changed as a result of the road closures. General areas of use as well as habitat selection by elk within those areas during the hunting season appeared to be governed primarily by previous traditions and social behavior associated with the rut. During each season hunters displaced elk from preferred areas to areas of similar but more extensive habitat. Road closures allowed elk to remain longer within preferred areas. (Excerpted Author's abstract)

Irwin, L.L. and J.M. Peek. 1983. Elk habitat use relative to forest succession in Idaho. Journal of Wildlife Management. 47(3):664-672.

Home range use and habitat selection by a nonmigratory elk (Cervus elaphus) herd in relation to forest succession in the cedar-hemlock (Thuja-Tsuga) zone of northern Idaho were studied through use of radiotelemetry. In spring, elk preferred grass-shrub and seral shrub successional stages for feeding and tall seral brushfields or pole-timber stands for resting. Elk fed in clear-cuts and seral shrub communities in summer and rested primarily within pole-timber stands on ridges. In autumn, elk shifted to pole-timber communities on mesic

slopes. No significant selection patterns occurred on winter range. Elk preferred to rest in areas over 400 m from traveled roads in all seasons. Home ranges contained more foraging area (35 vs. 20%) and less thermal and hiding cover (64 vs. 79%) than present in the study area overall. Selection of home ranges was related to forage production in seral stages of succession. Cover and human disturbance were important in habitat use in autumn. (Author's abstract.)

Kuck, L. 1984. Southeast Idaho wildlife studies (July 1978 to June 30, 1983), Idaho Department of Fish and Game, Job Completion Report W-160-r, 1246 pp.

A major research effort was conducted in the Soda Springs, ID area to document the impacts of phosphate mining on various wildlife species that use the area. The total findings of this study are included in a 1246 page report.

General findings on the impacts of mining development, which included road development, indicated that elk calves disturbed by mining activities move greater distances, used coniferous forest more and readily abandoned their traditional calf-rearing areas. Calf abandonment was not documented. More significant to big game during development of roads was the increased mortality rate caused by poaching. Natural mortality on deer, elk and moose in this areas was 41%, 27% and 14% respectively. Illegal kills in the mining area increased to 47%, 55% and 86% respectively for the same species.

Leckenby, D.A., and A.W. Adams, 1981. Eastern Oregon cover study - interim report. Oregon Department of Fish and Wildlife, Research and Development Section, La Grande, OR. 63 pp.

This paper deals with the interim findings of a long term elk and deer study by the State and Federal land/wildlife management agencies in the Blue Mountain region. One section addressed "Elk Use of Habitat Relative to Human Activity". Interim findings indicated that elk used habitats between 100-800 yards of human activities such as road activity, chopping wood, working on cars, etc. with partial to complete vegetative screens.

Leege, T.A. 1976. Relationship of logging to decline of Pete King elk herd. In: Proceedings, Elk-logging-roads symposium. University of Idaho, Moscow, ID. pp. 6-10.

Winter elk (Cervus elaphus) counts in the Pete King Creek drainage of north-central Idaho declined from 408 in 1957 to 63 in 1974. A study of the winter range indicated that elk numbers had decreased at a faster rate than forage had. Circumstantial evidence linked the accelerated elk decline to overharvest by hunters and the shifting of animals to different winter ranges. Causes were related to the construction of logging roads and the increased access they provided. (Author's abstract)

Leege, T.A. 1984. Guidelines for evaluating and managing summer elk habitat in northern Idaho. Wildlife Bulletin No. 11, Idaho Department of Fish and Game. 38 pp.

This document provides information on seasonal habitat preferences and food habits of elk during spring, summer and fall months in northern Idaho. Recommendations are made for coordinating logging, road buiding and livestock grazing with elk habitat preferences. An evaluation procedure is provided for estimating the effects of proposed land management activities on the quality of elk habitat. Computations take into consideration such things as quality, quantity and distribution of cover, forage, and security areas; and the density of open roads and livestock. Information for this document came from research literature and from numerous resource specialists in northern Idaho and adjacent areas.

Lyon, L.J. 1979. Habitat effectiveness for elk as influenced by roads and cover. Journal of Forestry (October), pp. 658-660.

Pellet counts conducted over an eight-year period confirmed that elk in western Montana tend to avoid habitat adjacent to open forest roads. The area avoided increases where the density of tree cover is low. Forest roads open to traffic cause available habitat to be less than fully effective. A method for determining the losses of effective habitat is presented. (Author's abstract)

Lyon, L.J. 1980a. Coordinating forestry and elk management. Transactions of the 45th North American Wildlife and Natural Resources Conference. Wildlife Management Institute, Washington, D.C. pp. 278-287.

This paper briefly summarizes the information from 10 years of research in the Montana cooperative elk logging study. It discusses the individual studies that made up the cooperative study, details components of the studies and then lists recommendations to mitigate or reduce the impacts of the components. Examples are road design, management, and area closures, timber harvesting and road construction.

Lyon, L.J. (Chairman). 1980. Montana cooperative elk-logging study. Annual Progress Report, U.S.D.A. Forest Service, Forestry Sciences Lab., Missoula, MT. 84 pp.

Progress report contains management recommendations for road locations and closures. In addition it gives a detailed progress report for the Long Tom and Chamberlain Creek elk-logging studies.

Lyon, L.J. (Chairman). 1981. Montana cooperative elk-logging study. Annual Progress Report, U.S.D.A. Forest Service, Forestry Sciences Lab., Missoula, MT. 90 pp.

Detailed progress reports are given for the abstracted studies shown below. In addition management recommendations are given.

Long Tom Creek Study

The 1980 field season was the third post-logging year of the study and the last full field season before final report preparation, which is expected to be completed by the end of 1982. Although data analysis is far from complete, results thus far indicate that the elk not only tended to avoid the sale area and its immediate vicinity during the logging activity, but also during the three post-logging years of the study. A brief explanation of proposed data analysis and associated computer programs is presented.

Chamberlain Creek Study

Objectives of this study are to describe elk distribution and elk use of several available environmental factors before, during and after logging. Habitat selection, movements and distribution of elk are reported for 1980. Although there was limited logging activity in the northeast portion of the CSA, pellet count results for 1980 still complement and reinforce our predisturbance conclusion that the primary factors influencing elk habitat use and distribution patterns are a combination of weather plus vegetative composition, structure, and phenology. With respect to logging and road construction activities the majority of elk use occurred between 0.5 and 2.0 miles from the source of the disturbance. In general, elk use increased with distance from open roads. As with the pellet count results, yearly changes in habitat use and distribution by radio-collared elk appeared to be associated with direct and indirect effects of variations in annual precipitation.

Elk Guidelines Validation

During the summer of 1980, we were able to complete field validation tests of elk habitat guidelines on five study areas in western Montana. In each area, 3-4 adjacent subunits of 2000-4000 acres were evaluated for cover/forage ratio, road density, and elk pellet-group densities. Our hypothesis was that individual subunits of habitat equally available to the same elk would be utilized at the level predicted by the guidelines.

Road density effects were evaluated using two different models, and the product of habitat potential (C/F) and habitat effectiveness (roads) was taken as the prediction of relative elk use. This prediction was compared to the actual elk use recorded on pellet group transects in each subunit. (Excerpted author's abstracts)

Lyon, L.J. (Chairman) 1982. Montana cooperative elk-logging study. Annual Progress Report, U.S.D.A. Forest Service, Forestry Sciences Lab., Missoula, MT. 89 pp.

This progress report contains elk-logging related management recommendations and detailed progress reports, the abstracts of which are given below.

Long Tom Creek Study

Field work for the Long Tom Creek Study was completed in 1981 and final data analysis is in progress. This report reviews the methodology of data collection and major analytical methods.

Chamberlain Creek Study

Objectives of this study are to describe elk use of several available environmental factors before, during, and after logging. During 1981, levels of human disturbance increased substantially in the core study area (CSA). All spur roads in the CSA were completed. Logging was started on BLM units during August 1981, and continued until the week before the opening of the general hunting season in October. Burlington Northern initiated logging on the west side of the CSA in early December 1981. Logging in the CSA will continue during 1982. Pellet count results indicated that, as in previous years, the primary influences on habitat use and distribution by elk were a combination of weather plus vegetative composition, structure, and phenology. Telemetry data supported this conclusion, but indicated that habitat preferences of elk were tempered by behavioral responses to human disturbances. This was especially true during rutting and hunting seasons. Radio-collared elk used areas within one-half mile of human activity less than availability during each season, significantly so during the calving, summer and hunting seasons. Conversely, areas greater than 2 miles from human activity were used greater than availability, significantly during the same seasons. Elk use of areas within 150 yards of an open road was greater than availability during the calving season, but less than availability the rest of the year. During the hunting season, no radio-collared elk were located within 150 yards of an open road; a significant deviation from availability.

Elk Guidelines Validation

During the summer of 1981, we completed fieldwork on six additional areas to bring the number of sample areas to eleven. In each area, three to four adjacent subunits of 2000-5000 acres have been evaluated for cover/forage ratio, road densities, and elk pellet-group densities. The test hypothesis remained the same: that subunits of habitat equally available to the same elk would be utilized at the level predicted by the guidelines.

This year, however, I tested six different methods of converting PI types to cover estimates, and evaluated three different C/F curves and about 30 different road models.

Results again confirm that subunits of habitat are utilized in the proportions indicated by C/F curves and road models. Some combinations, however, are far more accurate than others, and a few do not produce acceptable estimates. A combination using a single C/F curve and a single curve for roads produced the most reliable estimates. (Author's abstracts)

Lyon, L.J. 1983: Road density models describing habitat effectiveness for elk. Journal of Forestry, 81(9), pp. 592-595, 613.

Models depicting elk response to changes in the density of forest roads usually require extrapolation beyond the data. Results are likely to reflect the calculation technique rather than elk behavior. One technique described here does produce a model that coincides with actual elk behavior. This model can be used to predict habitat effectiveness for elk at road densities up to six miles per square mile. (Author's abstract)

Lyon, L.J. 1984. Field tests of elk/timber coordination guidelines. U.S.D.A. Forest Service, Research Paper INT-325. 10 pp.

During the summers of 1980 and 1981, field tests of elk/timber coordination guidelines were conducted on 11 study areas in Montana and northern Idaho. Evaluations of elk habitat based on different combinations of cover/forage functions and road models were compared to pellet group distributions. Elk response to variations in habitat quality was primarily determined by road densities. Acceptable road models predict over 50 percent of the variation in habitat use by elk. (Author's abstract)

Lyon, L.J. (Chairman). 1985. Coordinating elk and timber management. Final report of the Montana cooperative elk-logging study, 1970-1985. Bureau of Land Management/U.S. Forest Service/University of Montana/Montana Department of Fish, Wildlife and Parks. 53 pp.

This report summarizes a series of elk-logging studies in several areas of Montana over a period of years from 1970 to 1985. It includes a summary of research findings and management recommendations for road construction, road management, hunting season closures, clearcuts, etc.

Lyon, L.J. and C.E. Jensen. 1980. Management implications of elk and deer use of clear cuts in Montana. J. Wildlife. Manage. 44(2):352-362.

Elk (Cervus elaphus nelsoni), mule deer (Odocoileus hemionus), and white-tailed deer (O. virginianus) pellet-group densities were counted in and adjacent to 87 clear-cuts of various sizes and ages in eastern and western Montana. Pellet distributions suggest that animals enter clear-cut openings in search of better quality or greater quantities of forage. However, the willingness of animals to enter an opening is influenced by a requirement for security during the feeding period and is locally modified by the past experiences of animals in the available environment. Both elk and deer preferred clear-cuts with cover in the opening except where such cover inhibited forage growth. Both preferred openings in which logging slash was not a barrier to movement. Elk preferred smaller openings than deer, but were more tolerant of large openings - particularly where natural openings were already present in the environment. Elk use of clear-cuts was severely depressed by the presence of open roads and inadequate cover at the edge of the opening. (Author's abstract)

Lyon, L.J. and J.V. Basile. 1980. Influences of timber harvesting and residue management on big game. U.S.D.A. Forest Service Gen. Techn. Rep. Int-90 pp. 441-453. Intermt. For. Range Exp. Stn. Ogden, Utah.

Road construction and timber harvesting displace elk and grizzly bears at least temporarily. Elk sometimes accept logging disturbances, but usually do not return until harvesting ends. Increased contact between grizzly bears and humans is undesirable.

Logging slash may increase cover, but normally only obstructs animal movement. Broadcast burning produces more food plants for both elk and grizzly bears than other slash treatments. Although increased vehicle traffic adversely affects elk and grizzly bears, road closures should be carefully planned to achieve specific results.

Development of post logging big game habitat is a long-term process involving complex and dynamic relationships, not merely forage production. Elk, grizzly bears, and other big game require year-around habitat that satisfies daily and seasonal needs. (Author's abstract)

Lyon, L.J. 1984. Road effects and impacts on wildlife and fisheries. In: Proceedings of a forest transportation symposium: November 11-13, 1984 U.S.D.A. Forest Service, Rocky Mtn. Region.

Lyon, L.J. 1983. Road density models describing habitat effectiveness for elk. Journal of Forestry. 1983. 81(9). p. 592-595, 613.

Models depicting elk response to changes in the density of forest roads usually require extrapolation beyond the data. Results are likely to reflect the calculation technique rather than elk behavior. One technique described here does produce a model that coincides with actual elk behavior. This model can be used to predict habitat effectiveness for elk at road densities up to six miles per square mile. (Author's abstract)

Lyon, J.L. and A.L. Ward, 1982. Elk and Land Management. pp. 443-456. In: Elk of North America. Thomas, J.W. and D.E. Toweill eds. Stockpole Books. Harrisburg, PA.

The North American Elk was at one time the most widely distributed member of the deer family on this continent. Their distribution today is much smaller and they occupy less diverse habitats because they are too large to co- exist successfully with today's intense agricultural practices and human settlement. Elk in the western states are dependent upon public land management and the decisions that help benefit the herds so that healthy productive herds can be maintained.

Marcum, C.L. 1976. Habitat selection and use during summer and fall months by a western Montana elk herd. In: Proceedings, Elk-logging-roads symposium, University of Idaho, Moscow, ID. pp. 91-96.

Summer-fall habitat selection and use by a western Montana elk herd were investigated from 1971 through 1973. Objectives were to evaluate the interrelations between elk and various biological and physical habitat factors in an areaa which included roads and logging. Only a small part of the total results of the study is presented in this paper. Elk

within the study area demonstrated a wide tolerance for various environmental situations available to them. However, plant communities near water, which correspond especially with the Abies lasiocarpa/Galium triflorum habitat type, and the Abies lasiocarpa/Menziesia ferruginea type above 1975 m elevation, are probably the most critical areas on the summer-fall range in terms of their potential influence on elk productivity. No measureable benefits occured to elk as a result of logging on higher elevation ranges. Areas where roads were closed to vehicular traffic received greater elk use than areas where roads remained open, especially during hunting seasons.

McCorquodale, S.M., K.J. Raedike, R.D. Taber. 1986. Elk habitat use patterns in the shrub-steppe of Washington. J. Wildlife. Manage. 50(4):664-669.

Spatial and temporal habitat use patterns of elk in the shrub-steepe of Washington were studied from March through October 1983 and 1984. Four male and 4 female radio-collared elk were relocated a total of 782 times. Female elk preferred low elevation sagebrush associations during spring, late summer, and fall and riparian areas during the calving period and later summer months. Sagebrush stands were important bedding areas, particularly during late summer. Male elk selected sagebrush types during spring, summer and fall. Elk preferred low elevation topographic zones. The distribution of natural springs was an important determinant of habitat use patters for lactating female elk, but bull elk habitat use was less constrained by free water.

Morgantini, L.E., and R.J. Hudson. 1979. Human disturbance and habitat selection in elk. pp. 132-139. In: North American elk: ecology, behavior and management, Boyce, M.S., and L.D. Hayden-Wing, eds. University of Wyoming, Laramie, WY. 294 pp.

Pedersen, R.J. 1979. Management and impacts of roads in relation to elk populations. p.169-173. In: Proceeding Conference on recreational impacts on wildlands. U.S.D.A. Forest Service and U.S.D.I. National Park Service, Washington, D.C.

Wildlife managers need to understand the effects of harassment on survival, growth, behavior, and reproductive success of wild animals. Harassment may be defined as any activity which increases the physiological cost of survival or decreases reproduction.

Roads have become a subject of controversy with respect to many aspects of land management. Roads affect elk by directly removing habitat from production and indirectly by producing vehicle disturbance. A single lane road 6.7 m wide removes 1.1 ha per mile from elk production. A double lane road 10.36 m wide removes 1.7 ha per mile from elk production.

Elk were documented to move 250 m. to 4 km from logging and road construction. Elk use out to 804.6 m declined 154 percent for main roads, 108 percent for secondary roads, and 33 percent for primitive roads. Using 250 m as the zone adjacent to roads avoided by elk, 80.6 ha of habitat is removed from elk production.

There is a need to create an awareness about roads in relation to environmental effects and an urgent need to consider roads in terms of long range productivity. (Author's abstract)

Perry, C. and R. Overly. 1976. Impacts of roads on big game distribution in portions of the Blue Mountains of Washington. pp. 62-68. In Elk-Logging-Roads Symposium Proc., University of Idaho at Moscow.

Roads were grouped into three classifications based on their character and corresponding use. Big game distribution was measured by pellet group analysis and stratified by topographic and vegetative features of the landscape. Generally, we found that roads reduce big game use of adjacent habitat located from road edge to more than one-half mile away. This impact was greatest along "main" roads and through open vegetation types, and diminished with reduced road quality and increasing vegetation density. (Author's abstract)

Ream, R.R., R.C. Beall, and C.L. Marcum. 1974. Sapphire Divide Study. In E.O. Allen (Chairman) Montana Elk-Logging Studies, Progress Report. pp. 85-103.

This study was initiated in 1970 to determine the environmental requirements of elk and the influence of forest land management on elk in the Sapphire Mountains. kl Some of the results or finding were presented in annual reports, master's thesis, Ph.D. thesis and professional papers.

Conclusions reported is this document, that related to elk-logging-road situations, was that initiation of logging activity caused an initial avoidance response by elk. However, elk appeared to become conditioned to logging activity and after 14 to 21 days and resumed normal activity. Logging of an area alters elk habitat and may create an adverse ecological situation which is avoided by elk for long periods of time.

Rost, G.R., and J.A. Bailey. 1979. Distribution of mule deer and elk in relation to roads. J. Wildlife Management 43(3):634-641.

Responses of deer (Odocoileus hemionus) and elk (Cervus canadensis) to roads were assessed by counting fecal-pellet groups near roads on winter ranges. Data were obtained in Colorado in shrub and pine habitats adjacent to paved, gravel, and dirt roads east of the continental divide; and in shrub and juniper woodland habitats west of the divide. Deer and elk avoid roads, particularly areas within 200 m of a road. Road avoidance was greater (1) east, rather than west, of the continental divide, (2) along more heavily traveled roads, (3) by deer, when compared to elk, and (4) for deer in shrub habitats when compared to pine and juniper habitats. Because of less snow accumulation, winter habitat is more available to cervids east of the continental divide where more pronounced avoidance of roads presumably results from a greater availability of habitat away from roads. (Author's abstract)

Schultz, R.D. and J.A. Bailey. 1978. Responses of Rocky Mountain National Park Colorado USA elk to human activity. Journal of Wildlife Management. 42(1). pp. 91-100.

Responses of Rocky Mountain National Park elk (Cervus canadensis) to human activities were quantified in autumn 1974 and winter-spring 1975. During autumn, numbers of elk seen, rates of bugling, times arrival and departure of elk to and from meadows, and harem bulls' activities were analyzed for relationships with traffic volume and tourist activities. Results suggested small effects of traffic volume upon elk, but no trends were statistically significant. People approaching animals off roads usually caused elk to leave open areas. Harassing elk in 2 meadows on alternate weeks during winter and spring did not affect their distribution or observability on winter ranges. Elk made greater use of areas near roads as the winter-spring study progressed, suggesting slight avoidance of roads when forage was more abundant earlier in winter. Wintering elk often used a residential area at night when human encounters were minimal. During winter and spring, elk were approached significantly closer during darkness with artificial lights than during daylight. These elk, which experienced little or no hunting, were very visible and were disturbed little, if any, by normal on-road visitor activities. (Author's abstract)

Theissen, J.L. 1976. Some relations of elk to logging, roading and hunting in Idaho Game Management Unit 39. pp. 3-5. In: Proceedings, Elk-Logging-Roads Symposium Proc., University of Idaho at Moscow.

Since 1960, intensive forest management practices including timber harvest and road-building have been applied extensively in west central Idaho. Elk populations have declined significantly since 1964 in this area. In 1973, approximately 75 percent of all elk harvested in the Boise River area were taken from roadless and undisturbed areas, which comprise about 25 percent of the timbered portions of this drainage. (Author's abstract)

Thill, R.E., P.F. Ffolliott, and D. R. Patton. 1983. Deer and elk forage production in Arizona mixed conifer forests. U.S.D.A. Forest Service Research Paper RM-248, 13 p. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.

Mean forage production levels were closely associated with overstory basal area (BA), diminishing rapidly with increasing stand densities. Estimated total deer and elk forage on unlogged sites in mid-August is 82 pounds per acre (ovendry weight) at BA 50, versus 4 pounds per acre at BA 400. Eight and 16-year-old clearcuts produced 225 and 649 pounds per acre of potential forage, respectively. Although clearcuts and older thinned sites produced more potential deer and elk forage than unthinned sites, maximum utilization of this additional forage can only be achieved through judicious integration of forest and wildlife management practices. Utilization of additional forage is influenced by size, shape and juxtaposition of cutting units, availability of water, logging slash treatment and design of roads as they influence disturbance from humans.

Thomas, J.W. (editor). 1979. Wildlife habitats in managed forests -- the Blue Mountains of Oregon and Washington. U.S.D.A. Forest Service, Agriculture Handbook No. 553. 512 pp.

This book provides an extensive look at wildlife management in the Blue Mountains. It includes, among other things, information on the habitat effectiveness implications, hunter implications, and mitigation of adverse impacts for roads on deer and elk.

U.S. Department of Agriculture. 1985. Proposal by the technical committee of the Jackson Hole cooperative elk studies group for restricting public use on a big game winter range. Bridger-Teton Natinal Forest/National Elk Refuge. 4 pp.

After collecting elk winter use data for three years on the Jackson Hole Elk Refuge, the Jackson Hole Cooperative Elk Studies Group concluded that public use on the Curtis Canyon road was preventing elk use on an area 1/2 mile on either side of the road. This area was producing 1,229 tons of forage that was receiving less elk use than it should be. Forage lost because of human activities was being made up in artificial feeding at a cost of $93-117/ton of cubes and pellets, respectively. The refuge recommended closure of the road from 12/1 to 4/30 to solve the problem.

Ward, A.L. 1973. Elk behavior in relation to the multiple-use on the Medicine Bow National Forest. Proceedings of the Western Association of Game and Fish Commission. 53. pp. 32-43.

Telemetry was used to monitor elk behavior in relation to multiple uses on the Medicine Bow National Forest in southern Wyoming. Elk and cattle appeared to be socially compatible where there is an adequate food supply. Traffic on Forest Service systems roads has little effect on elk activity, especially beyond 300 yards. Interstate 890 acts as a barrier to elk movement. Elk preferred to be at least one-half mile from people engaged in out-of-vehicle activity such as camping, picnicking, fishing and harvesting.

Ward, A.L. 1976. Elk behavior in relation to timber harvest operations and traffic on the Medicine Bow Range in south-central Wyoming. In: Proceedings, Elk-logging-roads symposium. University of Idaho, Moscow, ID pp. 32-43.

Abstract

Radiotelemetry, time-lapse photography and counts of elk tracks on roads were used to gather data on elk behavior in relation to timber harvest and traffic on the Medicine Bow Range for the past four years. Elk preferred to be at least 800 m (0.50 mile) from people engaged in clearcut timber harvest or cleanup operations. Elk moved back to the timber harvested areas soon after human activity stopped. Traffic on Forest Service roads (logging, recreations, etc.) had little effect on elk activity, especially that beyond 400 m (0.25 mile) from the road. Heaviest elk road crossings occurred where desirable feeding sites (clearcuts, natural openings) are near the road. Slow vehicle speed and low traffic during elk activity periods, usually under low light conditions or at night, limited accidents and elk disturbance.

Access roads to Public lands are an important factor that needs to be considered when managing for viable elk populations. Increased roads effects elk in two primary ways:

1) road and/or logging debris may create physical barriers to elk movement and

2) roads tend to increase the probability of year-round disturbance by human activities.

Extensive road systems in elk use areas reduce the amount of time required to harvest allowable number of animals and may displace animals in low quality habitat. Both have significant management implications. Reports and studies have shown that elk avoid roads. The width effected varies from 0.25 to 1.8 miles based on vegetation cover, type of activity and frequency of the activity.

The effects of roads can be offset by implementing road closures during key periods of elk use of human use and by road layout and design.

Ward, A.L. 1985. The response of elk and mule deer to firewood gathering on the Medicine Bow Range in south-central Wyoming. Proceedings of the 1984 Western States and Provinces Elk Workshop ed. R. Wayne Nelson. Edmonton, Alberta Fish and Wildlife Division, Wildlife Branch. pp. 28-40.

More than 1,000 cords of firewood were removed by the public from the North Fork and Rock Creek Park area of the Medicine Bow National Forest during the summer and fall of 1980. Telemetered elk and their associates were disturbed by the presence of humans and preferred a buffer area of 800 m. Telemetered mule deer were more tolerant of the disturbance and continued to use the area although they generally stayed in the trees. Because firewood gatherers are so sporadic and scattered, it may become necessary to control their access in order to allow elk and mule deer to use their preferred habitat. (Author's Abstract)

Ward, A.L. 1985. Study of elk in the Little Snake Known Recoverable Coal Resource Area (KRCRA) of southeastern Wyoming. Final Report. Rocky Mountain Forest and Range Experiment Station. Laramie, WY pp. 188.

The six radio-collared elk monitored during this study showed a preference for timbered areas with lower road density or impassable roads due to snowdepths. The road density does not appear to be as critical a factor as the weather and consequent snowdepths; however, during the second half of the season many of the elk moved to lower elevations and less snow. This movement made them more vulnerable to hunters. Individual elk movements were difficult to predict. The combination of varied hunting pressure and the build-up of 6 to 16 inches of snow complicated elk habitat use. They moved downhill to get out of the deep snow and tried to stay away from hunters by finding areas where access was reduced either by snowdepths or restricted by private property.

Ward, A.L. and J.J. Cupal. 1979. Telemetered heart rate of three elk as affected by activity and human disturbance. In: Dispersed Recreation and Nat'l. Res. Manage, a Symposium. Utah State University, Logan, Utah pp. 47-56.

Telementry from confined and free-roaming elk (Cervus canadensis) carrying implanted transmitters and neck collar repeaters showed immediate and readily discernible responses in heart rate owing to activity and human disturbances. Close-range gunshots and humans on foot consistently produced more reaction than moving automobiles, motorbikes, and low flying aircraft. (Author's Abstract)

Ward, A.L., J.J. Cupal, G.A. Goodwin, and H.D. Morris. 1976. Effects of highway construction and use on big game populations. Rep. No. FHWA-RO-76. Federal Highway Administration, Washington, D.C. 92 pp.

Pronghorn antelope (Antilocarpra americana), mule deer (Odocoileus heminous), and elk (Cervus canadensis) are affected by right-of-way fences and highway traffic. At least 153 antelope, 561 mule deer, and 10 elk have been killed through vehicle accidents along a 55-mile section of I-80 west of Laramie, Wyoming, during a 5.5-year period. Since antelope are reluctant to jump fences and use underpasses, I-80 is a barrier and the herds are managed accordingly. Antelope can be kept off the highway by maintaining good woven wire fences and preventing snow from drifting over the right-of-way fence. Mule deer jump right-of-way fences, but can be forced to use underpasses by using deer-proof fencing. Both resident and migratory mule deer are affected by roads and traffic. Proper management should provide safe deer crossings thus increasing the safety of the highway user. Since elk are large, they present a greater hazard to motorists, and should be discouraged from crossing highways by proper fencing and road location. New techniques using heart-rate telemetry shows great potential for use in further studies of animal behavior in relation to the ever increasing activities of man. (Author's abstract)

Data are given in this report where heart rate of elk is monitored under the influence of differing human activity such as a vehicle traveling at a high rate of speed on a highway vs a slow moving vehicle on a mountain road.

Whitmer, G.W. and D.S. DeCalesta. 1985. Effect of roads on habitat use by Roosevelt elk. Northwest Science. 59(2) p. 122-125.

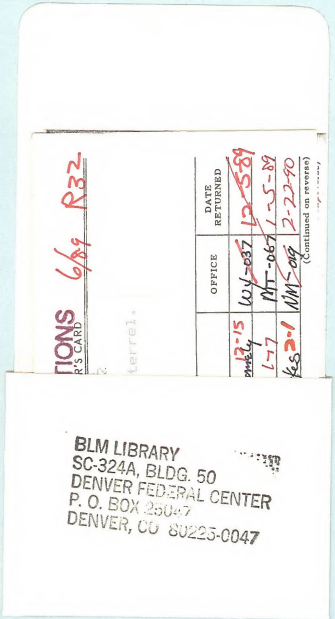
Radio locations of 6 female Roosevelt elk (Cervus elaphus roosevelti) were monitored for one year in the central Coast Range of Oregon. Frequency distribution of elk from paved and spur roads were compared with distributions of 200 randomly located points about paved and spur roads. Elk were located at half the expected frequency within a 500 m wide band surrounding paved roads. Significantly fewer ($P<0.05$) elk observations also were noted for a narrower band (125 m) about spur roads open to vehicular traffic, but no differences existed for elk locations about spur roads closed to vehicles. Effect of roads on elk use of habitat may be mitigated by a system of road closures. (Author's abstract)

Will, G.C. 1979. Size of spring-summer-fall elk home range in Region 4. In: elk surveys and inventories. Federal Aid Project W-170-R-3. Idaho Department of Fish and Game.

Abstract

Between 1973 and 1978, 100 adult cow elk in Region 4 (managements units 43, 44 and 48) were trapped or immobilized and fitted with collars containing radio transmitters. Annual fixed-wing monitoring between June 1 and November 18 resulted in sufficient data to compute 71 different spring-summer-fall home ranges for 56 cows. Average home range was 1617 hectares (3963 acres) and ranged from 90 to 6195 hectares.

In 1973, an elk telemetry study was initiated in Region 4 designed primarily to ascertain seasonal ranges and migration routes of elk north of the Snake River on the Boise and Sawtooth National Forest and on BLM lands in management units 43, 44, 45, 46 and 52. Secondary objectives were to determine size of home range and response to roads associated mostly with logging activities. The results demonstrated a strong avoidance of areas within 0.75 miles of roads and a strong selection for roadless areas beyond 2 miles from a road.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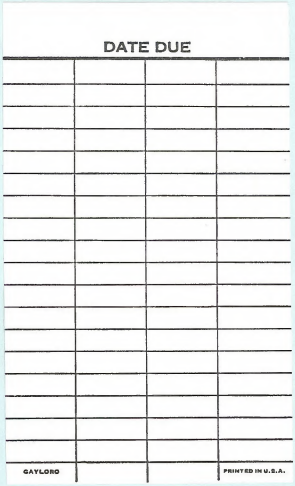
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